Electronic Journal of Plant Breeding, 8(1): 38-45 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00005.9

Research Article

Genetic variability and character association study for different morphological traits and path analysis for grain yield of rice under irrigated and rainfed condition

Hemant Sahu[1], Ritu R. Saxena[1] and S.B. Verulkar[2]
[1]Department of Genetics and Plant breeding, IGKV, Raipur (C.G.)
[2]Department of Plant Molecular Biology and Biotechnology, IGKV, Raipur (C.G.)
E-mail: hemant.sahupant@gmail.com

(Received: 01 Aug 2015; Revised: 04 Feb 2017; Accepted: 15 Feb 2017)

Abstract
Seventy one rice genotypes were studied for genetic variability, correlation and path analysis under irrigated and rainfed condition. The PCV values were greater than GCV, revealing little influence of environment in character expression. Analysis of variance was found to be significant for most of the traits, indicating that there is existence of genetic variability for these traits. High values of heritability along with genetic advance were observed for biological yield and harvest index. Grain yield was highly significantly and positively correlated with days to 50 per cent flowering, biological yield and harvest index, panicle length, flag leaf width and second leaf width under irrigated, whereas under rainfed condition panicle length and harvest index showed significant and positive correlation with grain yield. Biological yield and harvest index had positive direct effect on grain yield, hence selection of these two traits for grain yield will be effective.

Key words
Genetic variability, correlation coefficients, drought stress, heritability, genetic advance, yield

Introduction

Rice (*Oryza sativa* L.) is one of the staple cereal crops of the world and it is the world's most important food crop and a primary source of food for more than half the world's population and is the predominant staple for 15 countries in Asia and Africa. In India, it accounts for more than 40 % of food grain production. It is grown in 44.6 million hectare under 4 major ecosystems with annual production of 96.4 million tons Nandan *et al.* (2010). The periods of water shortage in soil or air often were happened during the life cycle of plants, even outside the drought and semi-drought regions. Plant responses to water deficit are complex including compromise changes or harmful effects. Drought conditions or water deficit stress in dry agro-ecosystems have a severe effect on rice production and they cause a meaningful decrease on its yield. As a result, increase of resistance to drought stress especially in rice, that is the main agricultural crops in Asia, is necessary (Singh, 2003; Widawsky and O'Toole, 1990). In many Asian countries, rice production would be decreased due to drought stress. Plant breeding and introducing drought resistant varieties as well as improve of drought resistance mechanisms will be useful to solve this problem. Plant varieties with high yield are generally dwarfed and have high harvest index and in comparison with the other cultivars but if the drought occurs during the last stage of growth, these cultivars will escape from drought stress. Drought resistance cultivars escape from severe drought stress occurred at the end of the rain season, by early flowering mechanism (Jearakongman *et al*, 1995).Drought stress during the vegetative growth, flowering and terminal period of rice cultivation, can interrupt floret initiation Causing spikelet sterility and grain filling, respectively (Botwright Acuna *et al*., 2008).

Materials and methods

The experiment was carried out under optimum irrigation and rainfed conditions in the research farm located at IGKV, Raipur, (21^0 16' N and 81^0 36' E at altitude of 289.6 meter above sea level) Chhattisgarh. The yearly average perception was 1249mm. The seventy one lines of the cross Swarna Sub-1 x IR 86918-B-305 of BC_1F_7 generation were sown in Randomized Block Design (RBD) with two replications. Initially the cross was attempted in the year *Kharif* 2014. A standard spacing of 15 x 15 cm was adopted for transplanting single plant per hill. All deep water irrigation operations were done until 20 days after transplanting, until the establishment of seedlings and then drought stress was induced by irrigation with holding while under normal condition i.e., in irrigated condition the rice plants were irrigated completely until 10 days before harvesting. Recommended packages of practices were followed during the crop growth period. Observations were recorded for eleven characters *viz*., days to 50 per cent flowering (DTF), plant height in cm (PH), panicle length in cm (PL), flag leaf length in cm (FLL), flag leaf width in cm (FLW), 2^{nd} leaf length in cm (SLL), 2^{nd} leaf width in cm (SLW), length of last internode in cm (LLI), biological yield (BY)in g, harvest index (HI) in percent and grain yield in g (GY). The data after compilation for each character was subjected to standard method of analysis of variance following

Panse and Sukhatme (1967), genotypic coefficient of variation (GCV) in percent and phenotypic coefficient of variation (PCV) in per cent, heritability in broad sense in percent (h^2) and genetic advance as per cent of mean were estimated by the formula as suggested by Burton (1952) and Johanson*et.al.* (1955). Genotypic and phenotypic correlation coefficients were calculated following Miller *et al.* (1958). Path coefficient analysis was estimated according to the method suggested by Dewey and Lu (1959). All these eleven traits were recorded under both condition i.e. irrigated (controlled environment) and rainfed (stress environment) during wet season 2014.

Results and discussion

The success of plant breeding depends on the amount of genetic variability present in a crop species and its germplasm. For improving productivity, the presence of genetic variability for economic traits is a key factor. Variability can be created by hybridization and the variability thus created need to be assessed in segregating populations. Therefore, the present investigation was carried out to assess the variability in genetically advanced genotypes of rice. The experiment comprising 71 genotypes were grown under two condition *viz*., water stress condition (rainfed) and non-stress condition (irrigated) during *Kharif* 2014. The results of the present investigation for various genetic parameters were as follows:

The mean squares for analysis of variance (ANOVA) of yield and yield contributing traits for both conditions (irrigated and rainfed conditions) are given in table 1. Analysis of variance revealed significant variation for most of the characters under both the conditions ($p<0.01$ and 0.05). The mean sum of square due to genotypes showed significant differences for all the traits under study except plant height. However, second leaf length under irrigated condition and panicle length and plant height under rainfed condition exhibited non-significant results thereby depicting less to no variability.

The genetic variability parameters for eleven traits are presented in table 2. Days to 50 percent flowering was found to be similar in both the conditions. Minimum duration for days to 50 percent flowering was 75.5 days for both the condition, whereas maximum102.5 days and 103 days for irrigated and rainfed condition with the general mean of 94.90 and 95.56 days, respectively. Line numbers 25 and 28 were early maturing under both the condition. Apart from these two lines, the line numbers 24 and 25 were also early maturing under for rainfed and irrigated condition respectively. Line number 52, 53 and 70 were late maturing under irrigated condition, whereas line number 47 was found to be late maturing type under rainfed situation. Plant height was found more in irrigated condition as compared to rainfed condition. It ranged from 80.3 cm to 219 cm and 76.1 cm to 131.3 cm with the general mean of 109.06 cm and 96.08 cm for irrigated and rainfed condition, respectively. Panicle length was obtained slightly higher in irrigated condition (24.69 cm) compare to rainfed (24.11 cm).Whereas, range of panicle length was found more in rainfed (18.5 to 31.6 cm) as compared to irrigated condition (18.9 to 30.6 cm).Line number 59 and 33 exhibited to have high panicle length in irrigated and water stress condition, respectively. Flag leaf length showed the mean of 32.63 cm and 29.72 cm for irrigated and rainfed situations, respectively. The range of variation was more in irrigated condition (21.9 cm to 47 cm) as compared to rainfed (19.7 to 43 cm).The general mean of flag leaf width was 1.43 cm and 1.21 cm in irrigated and rainfed condition and the range was between 1.04 cm and 1.78 cm for irrigated and 1.0 cm and2.6 cm for rainfed condition. But maximum flag leaf width was reported under rainfed situation. General mean for length of last internode was reported superior in case of irrigated (35.24 cm) compared to rainfed (29.92) condition. Similarly, biological yield was also more in case of irrigated condition. In the present investigation biological yield ranged from 1054 to 3152 g and 943 to 2339 g in irrigated and rainfed conditions, respectively. Line number 24 and 48 exhibited maximum biological yield under irrigated and rainfed condition respectively.

The general mean of harvest index (HI) in irrigated condition (42.22 %) was found almost double then the rainfed condition (20.9 %). The lowest harvest index (0.8%) was reported under rainfed situation whereas maximum harvest index (54.3 %) was found in case of irrigated condition. Line number 8 (55.48 %) and line number 19 (44.23 %) reported to have high harvest index in irrigated and rainfed situation respectively.

Grain yield (GY) under irrigated condition (959.08 g) was superior to the rainfed condition (288.55 g). The values of grain yield were ranged from 407 g to 1333 g and 15.5 to 534 g for irrigated and rainfed conditions, respectively. Line number 7 exhibited highest grain yield under both the situation. Table 3 represent top five high yielding lines. It clearly exhibit that grain yield under irrigated condition is more than the double the rainfed yield, because of proper management under irrigated condition.

The results of phenotypic coefficient of variation (PCV) and genotypic coefficients of variation (GCV) are presented in table 2. The magnitude of PCV was higher than the GCV under both the conditions. The PCV and GCV provide a measure to compare the variability present in the traits.

GCV and PCV were classified as suggested by Sivasubramanian and Madhavamenon (1973). Grain yield was the only character to have high PCV coupled high GCV under irrigated (normal) and water stress conditions. Plant height followed by biological yield recorded high PCV values and second leaf length and harvest index exhibited moderate to high PCV values in both the situations. The high variation in harvest index and grain yield especially under drought stress conditions gives promising information about applying these traits in accordance with the goals of breeding program. These results are in agreement with the findings of Prasad *et al*. (2001) and Zahid *et al*. (2006) who also reported maximum variation for these traits.

The broad sense heritability can be used as a predictor in the selection procedure (Allard, 1960). Heritability estimate is an important parameter which helps the breeder for selection of a plant trait that is high heritable as compared to a trait which is less heritable. Days to 50 per cent flowering were the only trait to having high heritability in broad sense under irrigated and rainfed condition. Grain yield exhibited moderate heritability in both the conditions. Biological yield exhibiting moderate heritability under irrigated condition and low under rainfed condition. High heritability for harvest index was observed under rainfed condition only and low during irrigated condition. Kumar *et al*. (2007) reported that, the heritability of rice under water stress is lower than the optimal irrigated condition.

Grain yield showed high magnitude of genetic advance as percent of mean in irrigated as well as rainfed conditions. However, biological yield, plant height, Flag leaf length recorded high genetic advance in irrigated and harvest index in rainfed condition only. Grain yield showed high genetic advance and moderate heritability under irrigated and rainfed situation respectively. It reveals that character is governed by additive gene effects and low to moderate heritability is being exhibited due to high environmental effect and selection may be effective. These two parameters are helpful for selection to improve grain yield in rice. The results are supported from the findings of Anandrao *et al.* (2011), Akhtar *et al.* (2011), and Shrivastava *et al.* (2014). Overall, grain yield was the trait to have high PCV and GCV coupled with broad sense heritability and genetic advance as percent of mean.

The correlation or the association analysis establishes the relationship between the two traits. It may be either positive or negative. The results (Table 4) indicated that in both the conditions, the magnitude of genotypic correlation is higher than the phenotypic correlation.

Grain yield exhibited significant association with days to 50 per cent flowering followed by Second leaf width. However, these two traits recorded positive association under irrigated and negative association under rainfed condition. Apart from this, harvest index was the only trait representing significant and positive association with grain yield in both conditions. Furthermore, panicle length followed by flag leaf width and biological yield exhibited positive association with grain yield in irrigated condition. Garrity and O'Toole (1994) have reported that there is positive correlation between panicle fertility percentage and paddy yield under water stress condition.

Days to 50 per cent flowering showed positive and significant association with panicle length under irrigated condition and significantly negative association under rainfed condition. Likewise plant height with flag leaf length; days to 50 % flowering with second leaf width; flag leaf width with second leaf width; plant height, panicle length and flag leaf length with length of last internode; days to 50 % flowering with biological yield and harvest index showed significant and positive correlation in both the conditions. The correlation coefficient value was found significant indicating association between two characters is high. The result of present investigation indicates the relative utility of each traits for selection with respect to grain yield. This finding is similar to Pandey *et al.* (2012) and Mishra *et al.* (2014). Significant and positive correlation between yield and other traits showed that each factor leads to changes in these traits will change correlation coefficients.

In the present study path coefficient analysis has been conducted by considering grain yield as dependent variables. Path analysis under irrigated condition showed that BY had highest positive direct effect on grain yield followed by harvest index, second leaf width, plant height and second leaf length, it reveals the true relationship between them and direct selection for this traits will be rewarding for yield improvement. The characters like days to 50 per cent flowering, flag leaf length and flag leaf width exhibit negative direct effect but these character had strong positive indirect effect *via* biological yield; indicates indirect selection through such traits will be live in yield improvement. In the present investigation under irrigated condition it was found that days to 50 per cent flowering, panicle length and flag leaf length exhibit negative direct effect but significant and positive correlation with grain yield. In contrary to these biological yield, biological yield, harvest index, flag leaf width, second leaf length and second leaf width exhibit positive correlation with grain yield as well as positive direct effect, indicating the true relationship among these traits in both the situation. This may indicate that the direct selection for these traits would likely be effective in increasing grain yield.

Whereas under rainfed condition highest positive direct effect was found in case of harvest index followed by biological yield, second leaf width, length of last internode, second leaf length and plant height. Rest of the characters exhibited negative direct effect. The characters biological yield and harvest index had positive direct effect and exhibited significant positive correlation with grain yield, indicating the true relationship among these traits in both the situation. Days to 50 per cent flowering and Flag leaf width exhibit negative direct effect as well as correlation with grain yield, whereas second leaf length, second leaf width and biological yield exhibit positive direct effect but negative correlation. Panicle length showed negative direct effect but positive correlation with grain yield. Length of last internode and harvest index were reported to show positive direct as well as correlation with grain yield. This may indicate that the direct selection for these traits would likely be effective in increasing grain yield.

When many traits are affecting an assumed character, splitting the total correlation into direct and indirect effects of cause would give more meaningful understanding to the cause of association between the dependent trait like yield and independent trait like yield component traits (Nandan *et al.,* 2010).

The residual effect of the present study was 0.02639 and -0.016 for irrigated and rainfed situation respectively, indicating that characters studied in the present investigation is sufficient to explain variability. This result gives an impression that some other major characters other than those involved in the present study might also contribute to yield. The results are in agreement with the findings of Mohsin *et al.* (2009), Bagheri *et al.* (2011) and Moosavi *et al.* (2015).

Conclusion

The results of this research showed that plant varieties with high yield are generally dwarf and have high panicle length, flag leaf length, flag leaf width, biological yield and harvest index and in comparison with the other cultivars but in occurance of drought during the terminal stages of growth, these cultivars will escape from drought stress and they will usually go flowering later than other cultivars with high panicle length, biological yield and harvest index. Hence, indirect selections for increasing the days to 50 per cent flowering, panicle length, flag leaf length, flag leaf width, second leaf length, second leaf width, biological yield and harvest index under optimum irrigation. Whereas under rainfed condition indirect selections for increasing the panicle length, length of last internode and harvest index and decreasing days to 50 % flowering, flag leaf width, second leaf length, second leaf width and biological yield can be suitable to improve paddy yield of rice under drought situation.

Acknowledgment

The first author gratefully acknowledges Indian Council of Agricultural Research (ICAR) for providing him financial assistance in terms of Senior Research Fellowship (SRF) during the period of the study. The author also express their deep sense of gratitude to the department of Genetics and Plant Breeding College of Agriculture, IGKV, Raipur, for providing experimental material and their assistance in data tabulation and analysis.

References

Akhtar, N., Nazir, M.F., Rabnawaz, A., Mahmood, T., Safdar, M.E., Asif, M. and Rehman, A. 2011. Estimation of heritability, correlation and path coefficient analysis in fine grain rice (*Oryza sativa* L.). *J. Anim. Plant Sci*., **21**(4):660-664.

Allard, R.W, (1960) Principles of plant breeding. John Whiley Sons Inc. New York. Pp 485.

Anandrao, S.D., Singh, C.M., Suresh, B.G. and Lavanya, G.R. 2011. Evaluation of rice hybrids for yield and yield component characters under North East Plain Zone. *The Allahabad Farmer,* **67**(1): 63-68.

Bagheri, N.A., Babaeian-Jelodar, N.A. and Pasha, A. 2011. Path coefficient analysis for yield and yield components in diverse rice (Oryza sativa L.) genotypes. *Biharean Biologist,* **5**(1): 32-35.

Botwright Acuna, T.L., Lafitte, H.R., and Wade, L.J. 2008. Genotype and environment interactions for grain yield of upland rice backcross lines in diverse hydrological environments. *Field Crops Res.,* **108**(2): 117-125.

Burton, G.W. 1952. Quantitative inheritance in pearl millet (P. typhoides L.).*Agron J.* **50**: 503.

Dewey, D.R. and Lu, K.H. 1959. Correlation and pathcoefficients analysis of components of crested wheatgrass seed population. *Agron. J*., **51**: 515-518.

Garrity, D.P. and O'Toole, J.C. 1994.Screening for drought resistance at the reproductive phase. *Field Crops Res.,* **39**: 99-110.

Jearakongman, S., Rajatasereekul, S., Naklang, K., Romyen, P., Fakai, S., Skulkhu, E., Jumpaket, B. and Nathabutr, K. 1995. Growth and grain yield of contrasting rice cultivars grown under different conditions of water availability. *Field Crop Res.,* **44**: 139–150.

Johanson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in Soyabean. *Agron J*., **47**(7): 314-315.

Kumar, R., Venuprasad, R. and Atlin, G.N. 2007. Genetic analysis of rainfed lowland rice drought tolerance under naturally-occurring stress in eastern India: heritability and QTL effects. *Field Crop Res.,* **103**(1): 42-52.

Miller, P.A., Williams, C.V., Robinson, H.F. and Comstock, R.E. 1958. Estimates of genotypic and environmental variance and covariance in upland cotton and their implication in selection. *Agron. J*. **50** (3): 126-131.

Mishra, V.K., Dwivedi, D.K. and Pandey, P. 2014. Consequence of Salinity on Biological Yield, Grain Yield and Harvest Index in Rice (Oryza sativa L.) Cultivars. *Environ. & Ecol.,* **32**(3): 964—968.

Mohsin T., Khan, N. and Naqvi, F.N. 2009. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in synthetic elite lines of wheat. *J. Food, Agri. and Envi.,* **7**: 278-282.

Moosavi, M., Ranjbar, G., Zarrini, H.N. and Gilani, A. 2015. Correlation between morphological and physiological traits and path analysis of grain yield in rice genotypes under Khuzestan conditions. *Biolog. Forum Int. J.,* **7**(1): 43-47

Nandan, R., Sweta and Singh, S.K. 2010. Character Association and Path Analysis in Rice (*Oryza sativa* L.) genotypes. *World J. Agric. Sci.,* **6**(2): 201-206.

Pandey, V.R., Singh, P.K., Verma, O.P. and Pandey, P. 2012. Inter-relationship and path coefficient estimation in rice under salt stress environment. *Int. J. Agric. Res.,* **7**(4):169-184.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

Prasad, B., Patwary, A.K. and Biswas, P.S. 2001. Genetic variability and selection criteria in fine rice (*Oryza sativa* L.). *Pak. J. Biol. Sci.* **4**:1188-1190.

Shrivastava, A., Mishra, D.K., Koutu, G.K. and Singh, S.K. 2014. Heritability and Genetic Advance Estimation From Parental Lines of Hybrid Rice. *Int. J. Sci. Res*., **3**(7): 11-13.

Singh, K.A. 2003. Enhancing rice productivity in water stressed environments. IRRI Publications DOI No: 10.1142/9789814280013_0013.

Sivasubramanian, V. and Madhavamenon, P. 1973. Path analysis for yield and yield components of rice. *Madras Agric. J.* **60**: 1217-1221.

Widawsky, D.A. and O'Toole, J.C. 1990. Prioritizing the rice biotechnology research agenda for Eastern India. New York, The Rockefeller Foundation.

Zahid, M.A., Akhtar, M., Sabir, M., Manzoor, Z. and Awan, T.H. 2006. Correlation and path analysis studies of yield and economic traits in Basmati rice (*Oryza sativa* L.). *Asian J. Pl. Sci.,* **5**: 643-645.

Table 1. Analysis of variance for eleven yield and yield attributing traits under irrigated and rainfed conditions

Source of variation	df	Mean sum of squares (Irrigated)										
		DTF	PH	PL	FLL	FLW	SLL	SLW	LLIN	BY	HI	GY
Replication	1	0.13	1590.24	0.25	8.46	0.004	745367	0.08**	4.87	295688**	144.20*	109432*
Treatment	70	95.54**	1346.29	7.26**	59.64**	0.05**	1008.63	0.03**	30.00**	398815**	67.67**	109142**
Error	70	0.70	510.12	3.22	13.33	0.011	922.62	0.08	8.25	41182	27.75	21207
		Mean sum of squares (Rainfed)										
Replication	1	0.25	9.75	191.73**	7.83	0.78**	6.59	0.08**	64.33*	49792	981.00**	217075**
Treatment	70	104.05**	468.99	15.67	37.82**	0.03**	66.32**	0.03**	35.59**	166482**	190.14**	28968**
Error	70	1.50	325.55	12.65	13.67	0.09	27.46	0.01	12.73	80856	17.42	6858.67

*, ** significant at 5 and 1 per cent probability level

Table 2. Genetic variability parameters for eleven yield and yield attributing traits under irrigated and rainfed conditions

Traits	Range				GM		PCV (%)		GCV (%)		h^2 (%)		GA as per cent of mean	
	Min. (I)	Max. (I)	Min. (R)	Max. (R)	(I)	(R)	(I)	(R)	(I)	(R)	(I)	(R)	(I)	(R)
DTF	75.5	102.5	75.5	103	94.90	95.56	7.31	7.60	7.26	7.49	98.5	97.2	14.89	15.22
PH	80.3	219	76.1	131.3	109.06	96.08	27.93	20.75	18.78	8.81	45.1	18.1	25.92	7.71
PL	18.9	30.6	18.5	31.6	24.69	24.11	9.27	15.61	5.76	5.10	38.6	10.7	7.36	3.44
FLL	21.9	47	19.7	43	32.63	29.72	18.51	17.07	14.75	11.69	63.4	46.9	24.21	16.49
FLW	1.04	1.78	1	2.6	1.43	1.21	11.88	11.24	9.64	7.78	4.5	47.9	16.17	11.57
SLL	24.8	58.6	29.4	55.1	43.88	40.43	70.82	16.94	14.95	10.90	55.8	41.4	6.49	14.44
SLW	0.9	1.44	0.65	1.27	1.17	1.03	12.15	12.38	9.08	9.39	81.3	57.6	13.97	14.56
LLI	26.5	43.1	16.1	42.3	35.24	29.92	12.41	16.43	9.36	11.30	41.8	47.3	14.53	16.01
BY	1054	3152	943	2339	2245.92	1445.56	20.88	24.33	18.83	14.31	67.5	34.6	34.97	17.35
HI	26.16	4.3	0.8	39	42.22	20.90	16.36	48.73	10.58	44.45	41.8	83.2	14.09	83.54
GY	407	1333	15.5	534.5	959.09	288.55	26.62	46.38	21.86	36.44	67.5	61.7	36.99	58.97

Days to 50 % flowering (DTF)
Plant height (cm) (PH)
Panicle length (cm) (PL)
Flag leaf length (cm) (FLL)
Flag leaf width (cm) (FLW)
2nd leaf length (cm) (SLL)
2nd leaf width (cm) (SLW)
Length of last internode (cm) (LLIN)
Biological yield (g) (BY)
Harvest index (%) (HI)
Grain yield (g) (GY)

Table 3. Top five Lines showing high grain yield in irrigated and water stress conditions

Line No.	Irrigated condition	Line No.	Rainfed condition (Water stress)
7	1333	7	534.5
51	1308	8	506
5	1285	13	477.5
48	1268	21	470.5
54	1266.5	31	458

Electronic Journal of Plant Breeding, 8(1): 38-45 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00005.9

Table 4. Association analysis for eleven yield and yield attributing traits under irrigated (I) and rainfed (R) conditions

Traits		PH	PL	FLL	FLW	SLL	SLW	LLI	BY	HI	GY
DTF	r_p	0.06	0.36**	0.32**	0.47**	0.15	0.54**	0.09	0.63**	0.28**	0.61**
(I)	r_g	0.08	0.62**	0.41**	0.59**	0.68**	0.72**	0.14	0.71**	0.43**	0.75**
DTF	r_p	-0.17	-0.28**	-0.19	0.19	-0.14	0.43**	-0.27*	0.26*	-0.34**	-0.21*
(R)	r_g	-0.39**	-0.91**	-0.27*	0.30**	-0.19	0.56**	-0.37**	0.49**	-0.37**	-0.25*
PH	r_p	1.00	0.34**	0.31**	0.12	0.03	-0.06	0.52**	0.08	-0.14	-0.06
(I)	r_g	1.00	0.67**	0.63**	0.19*	-0.09	-0.19*	0.80**	0.12	-0.38**	-0.12
PH	r_p	1.00	0.16	0.43**	0.02	0.38**	-0.15	0.36**	0.01	0.11	0.13
(R)	r_g	1.00	-0.87**	0.78**	0.22*	0.68**	-0.43**	0.75**	-0.22*	0.10	0.16
PL	r_p		1.00	0.60**	0.46**	0.10	0.38**	0.62**	0.31**	0.01	0.23*
(I)	r_g		1.00	0.89**	0.65**	0.93**	0.39**	0.69**	0.58**	0.11	0.49**
PL	r_p		1.00	0.06	-0.14	0.04	-0.04	0.22*	-0.28**	0.24*	0.11
(R)	r_g		1.00	-0.14	-0.33**	-0.37**	-0.46**	0.98**	-0.99**	0.99**	0.89**
FLL	r_p			1.00	0.37**	0.10	0.36**	0.53**	0.41**	-0.25*	0.15
(I)	r_g			1.00	0.53**	0.36**	0.49**	0.65**	0.53**	-0.42**	0.19*
FLL	r_p			1.00	-0.13	0.66**	-0.10	0.37**	0.05	0.03	0.09
(R)	r_g			1.00	-0.17	0.79**	-0.16	0.44**	-0.23*	-0.06	-0.08
FLW	r_p				1.00	0.11	0.65**	0.25*	0.55**	0.05	0.41**
(I)	r_g				1.00	0.66**	0.91**	0.27**	0.75**	0.07	0.60**
FLW	r_p				1.00	-0.14	0.22*	-0.12	0.22*	-0.17	-0.12
(R)	r_g				1.00	-0.04	0.51**	-0.29**	0.06	-0.20*	-0.23*
SLL	r_p					1.00	0.12	0.03	0.13	-0.06	0.07
(I)	r_g					1.00	0.98**	0.62**	0.66**	0.05	0.54**
SLL	r_p					1.00	0.02	0.27*	-0.04	-0.13	-0.12
(R)	r_g					1.00	-0.29**	0.33**	0.11	-0.22*	-0.25*
SLW	r_p						1.00	-0.0001	0.57**	0.09	0.45**
(I)	r_g						1.00	-0.12	0.86**	0.31**	0.86**
SLW	r_p						1.00	-0.34**	0.17	-0.38**	-0.32**
(R)	r_g						1.00	-0.61**	0.65**	-0.49**	-0.36**
LLI	r_p							1.00	0.10	-0.21*	-0.09
(I)	r_g							1.00	0.12	-0.31**	-0.11
LLI	r_p							1.00	-0.09	0.34**	0.35**
(R)	r_g							1.00	-0.65**	0.42**	0.37**
BY	r_p								1.00	0.18	0.77**
(I)	r_g								1.00	0.17	0.87**
BY	r_p								1.00	-0.40**	-0.02
(R)	r_g								1.00	-0.81**	-0.62**
HI	r_p									1.00	0.73**
(I)	r_g									1.00	0.64**
HI	r_p									1.00	0.89**
(R)	r_g									1.00	0.96**

*, ** significant at 5 and 1 per cent probability level. The upper and lower figures represent the r_p and r_g, respectively. Data for irrigated conditions are shaded.

Electronic Journal of Plant Breeding, 8(1): 38-45 (March 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00005.9

Table 5a. Direct and indirect effects of eleven yield and yield parameters under irrigated (I) condition

	DTF	PH	PL	FLL	FLW	SLL	SLW	LLI	BY	HI
DTF	**-0.12**	0.03	-0.02	-0.02	-0.15	0.08	0.27	-0.03	0.48	0.22
PH	-0.01	**0.37**	-0.03	-0.03	-0.05	-0.01	-0.07	-0.17	0.08	-0.20
PL	-0.07	0.25	**-0.04**	-0.04	-0.17	0.11	-0.07	-0.17	0.08	-0.20
FLL	-0.05	0.23	-0.04	**-0.05**	-0.014	0.04	0.19	-0.14	0.36	-0.22
FLW	-0.07	0.07	-0.03	-0.03	**-0.26**	0.08	0.35	-0.06	0.51	0.03
SLL	-0.08	-0.03	-0.04	-0.02	-0.17	**0.12**	0.41	-0.13	0.45	0.03
SLW	-0.08	-0.07	-0.12	-0.02	-0.24	0.14	**0.38**	0.03	0.59	0.16
LLI	-0.02	0.30	-0.03	-0.03	-0.07	0.08	-0.05	**-0.21**	0.08	-0.16
BY	-0.08	0.04	-0.02	-0.03	-0.19	0.08	0.33	-0.02	**0.68**	0.09
HI	-0.05	-0.14	-0.004	0.02	-0.02	0.01	0.12	0.07	0.12	**0.52**

Residual (G) = 0.02639

Table 5b. Direct and indirect effects of eleven yield and yield parameters under rainfed (R) condition

	DTF	PH	PL	FLL	FLW	SLL	SLW	LLI	BY	HI
DTF	**-0.01**	-0.02	0.03	0.05	-0.03	-0.04	0.14	-0.07	0.21	-0.51
PH	0.004	**0.06**	0.03	-0.13	-0.02	0.12	-0.11	0.15	-0.09	0.15
PL	0.01	-0.05	**-0.03**	0.02	0.03	-0.07	-0.11	0.23	-0.5	1.37
FLL	0.003	0.04	0.004	**-0.16**	0.02	0.14	-0.04	0.09	-0.09	-0.08
FLW	-0.003	0.01	0.01	0.03	**-0.09**	-0.01	0.13	-0.06	0.03	-0.28
SLL	0.002	0.04	0.01	-0.13	0.003	**0.18**	-0.07	0.06	-0.05	-0.3
SLW	-0.01	-0.02	0.01	0.03	-0.04	-0.06	**0.25**	-0.12	0.28	-0.67
LLI	0.004	0.04	-0.04	-0.07	0.03	0.06	-0.15	**0.19**	-0.28	0.57
BY	-0.01	-0.01	0.04	0.04	-0.01	-0.02	0.16	-0.13	**0.43**	-1.11
HI	0.004	0.01	-0.03	0.01	0.02	-0.04	-0.12	0.08	-0.34	**1.38**

Residual (G) = -0.0168